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A mathematical modelling of inner-resonance of tangent nonlinear cushioning packaging system with critical components

Jun Wang [a,b,*], Yasir Khan [c,**], Rui-Hua Yang [d], Li-Xin Lu [a,b], Zhi-wei Wang [e], Naeem Faraz [f]

[a] Department of Packaging Engineering, Jiangnan University, Wuxi 214122, China
[b] Key Laboratory of Food Packaging Techniques & Safety of China National Packaging Corporation, Wuxi 214122, China
[c] Department of Mathematics, Zhejiang University, Hangzhou 310027, China
[d] Key Laboratory of Science & Technology of Eco-textiles Ministry of Education, Jiangnan University, Wuxi, Jiangsu, China
[e] Packaging Engineering Institute, Jinan University, Zhuhai, China
[f] Modern Textile Institute, Donghua University, 1882 Yan'an Xilu Road, Shanghai 200051, China

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ABSTRACT

A dynamic model is proposed for a tangent cushioning packaging system based on critical components. Conditions for resonance are obtained by applying He's variational iteration method, which should be avoided in the cushioning packaging design. The results help us to understand the dropping damage mechanism of packaged products based on critical components.

1. Introduction

Packaged products can be potentially damaged by dropping, and it is very important to investigate the oscillation process of the packaging system. In the past, great efforts have been made in this special field. Newton's damage boundary concept [1] and succeeding modified damage evaluation approaches, such as fatigue damage boundary concept [2], displacement damage boundary concept [3] and dropping damage boundary concept [4], were widely utilized in packaging design. Despite the popularity of these concepts, some basic assumptions of all these theories have been questioned:

(1) The packaging system was considered to be a spring-mass, single-degree-of-freedom system.
(2) The cushioning packaging was treated as a simple linear or nonlinear spring. These may not be valid.

Most products, especially mechanical and electronic products, are composed of large numbers of elements, and the damage generally occurs at the so-called critical component. In order to prevent any damage, a critical component and a cushioning packaging are always included in a packaging system [5]. In our previous paper, a linear model governing the system was considered [6]. The oscillation in the packaging system is of inherent nonlinearity [7,8], the governing equations of inner-resonance of tangent nonlinear cushioning packaging system with the critical component can be expressed as

$$m_1\frac{d^2x}{dt^2}+k_1(x-y)=0 \tag{1}$$

* Corresponding author at: Department of Packaging Engineering, Jiangnan University, Wuxi 214122, China.
** Corresponding author.
E-mail addresses: packei@yahoo.com.cn, packie@126.com (J. Wang), yasirmath@yahoo.com (Y. Khan).

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